computer systems analysis and programming

PLANNING RESEARCH CORPORATION

computer systems analysis and programming

Planning Research Corporation is a professional service organization of 700 members dedicated to solving problems for industry and government through application of the physical, social, and life sciences.

The computer systems staff at PRC is one of the nation's largest and most experienced in the areas of analysis, programming, and systems implementation despite the fact that the Corporation does not engage in furnishing computer time or computer hardware products. Both PRC's size and its independence from equipment sales have proven valuable to its clients.

Size is important because computer programming is exactingly difficult work, requiring a variety of skills and experience. Not only must the programmer be expert in the techniques of his profession, but also he must be thoroughly familiar with the process being automated. PRC recognizes that quality in computer systems analysis and programming results from individual skill and, for the solution of many problems, a large staff is not required. However, many problems, both large and small, require a staff of the size and scope afforded by PRC.

Independence from the sale of computer time or hardware is important because it frees PRC from economic pressures that might compromise complete objectivity. When, at the completion of a system analysis, PRC recommends the installation of an expensive computer or some associated peripheral equipment, there is no question of conflict of interest — the recommendations are those best suited to the system studied.

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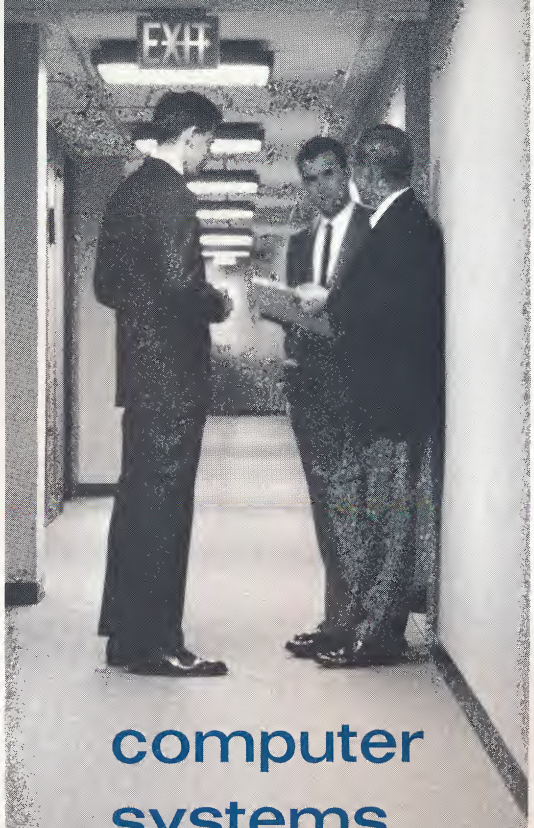


computer systems analysis

At times, Planning Research is at work even before a suitable computer exists for the system being developed. Designs can be developed for whole systems, including interface and input devices and special-purpose digital equipment. On systems planned around general-purpose computers, analysis more often consists of designing an information system.

The problem statement may be a simple sentence: "Automate my payroll," or "Plan an automatic inventory system." For such problems, PRC analyzes the data flow in the present system; conducts systems analyses that result in flowcharting the new system; and estimates the cost of obtaining and operating the automated system. When more complex assignments so demand, as in converting large filing systems from manual to automated processes, PRC subdivides the assignment into simple problem statements and proceeds as above. At this complexity level, there may be an added need for evaluating competing hardware systems. On very large contracts, as in preparing a control system to monitor the activities of all ships in the Pacific, PRC may analyze the flow of information throughout an entire military command, including information to and from other commands and agencies.

Information Flow (INFLO) Methodology

PRC analysts, while working with advanced information-handling systems, have developed a uniquely effective organizing system for gathering data and documenting data quality, accuracy, and completeness. This system is called INFLO.

INFLO is a proven technique that affords an efficient, rigorous description of the type and amount of information flowing through a system. The technique is composed of four elements: (1) the use of an appropriate, general language to define information flow; (2) the use of flowcharts for graphic representation of complex information relationships; (3) the generation and updating of an information flow data base; and (4) the generation of clear text descriptions of information flow from the up-to-date data base. These elements are combined into a cohesive whole that gives both the ADP user and ADP system designer an accurate and current picture of the processes that are candidates for automation. This includes the structure of information flow through a system, the relationships among the originators and receivers of such information, and the volume and frequency of transmission. With INFLO, an arbitrarily large data base may be examined as minutely or as grossly as desired by the selective generation of clear text reports edited from the complete data base.

Systems Analysis

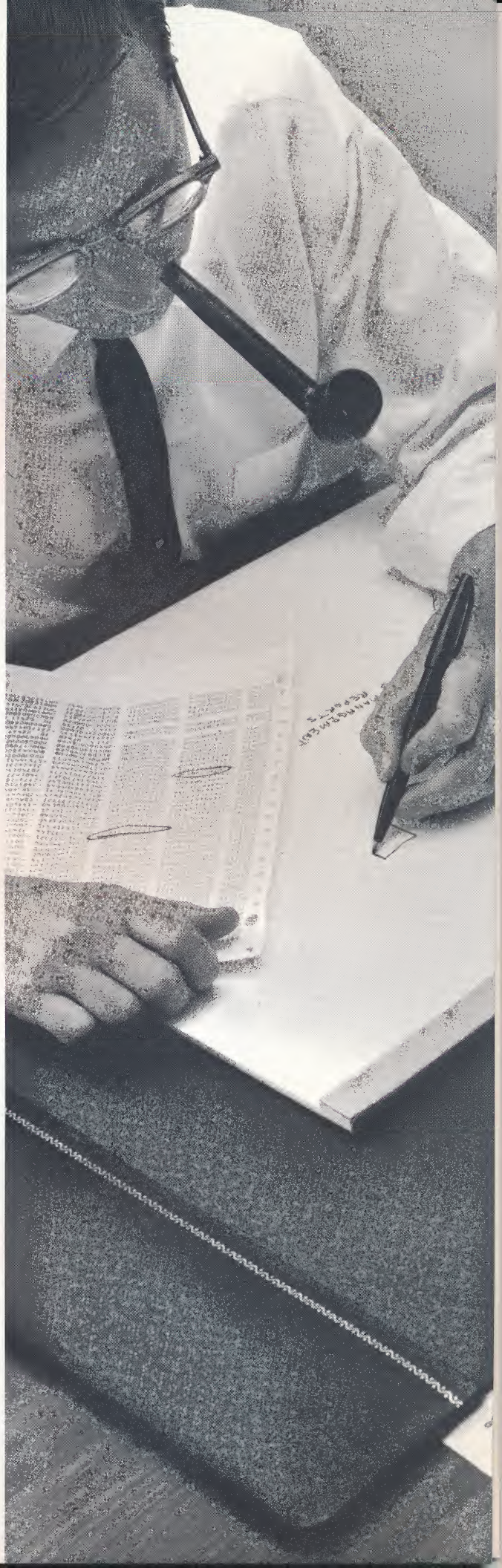
Systems analyses required by new applications are an area of special strength at PRC. Projects conducted by the firm include:

- Analyzing information flow inside an attack submarine, in terms of events, data required, and frequency of information transfer
- Investigating decision rules appropriate for an automated spare parts requisition system
- Designing an operational procedure for commanding satellite missions, including the responsibility for reducing the telemetry requirements of the system
- Synthesizing a concept for judging proposals for new computer systems, involving criteria needed by management in making decisions, data required in proposals to satisfy these criteria, and definition of elements of data for validating proposal data
- Examining the hardware and performance requirements of an automated distribution system in a telegraphic message center — future plans include modular expansion into a completely automated system
- Creating a standardized language and reporting system for an automated photo-intelligence system that provides trend analysis, fact correlation, and supporting information on thousands of subjects

Common to all these studies are the objectives PRC sets for itself in analysis projects: planning for system growth; taking advantage of the hardware improvements that will be available when the system is operational; avoiding operational concepts that require, rather than assimilate, hardware improvements; and spending as much time as necessary on-site. The last objective is highly important; PRC has the most capable staff to be found, but even they cannot design a system in absentia.

Technical Audit

PRC can provide management with an impartial third-party view of goals, achievements, and problem areas. When auditing operational systems, PRC examines every aspect of equipment capability, programming technique, file storage, scheduling, physical layout, work flow, and documentation. Throughout, PRC questions delay, expense, duplication, dead time, and the misuse of equipment. Computer systems in development can be audited for the same factors. Planning documentation, for example, can be especially vital if a key planner leaves the project team. A Planning Research audit is most valuable because only senior personnel participate. And only senior analysts have the ability to isolate and identify problems hidden in a welter of technical detail.



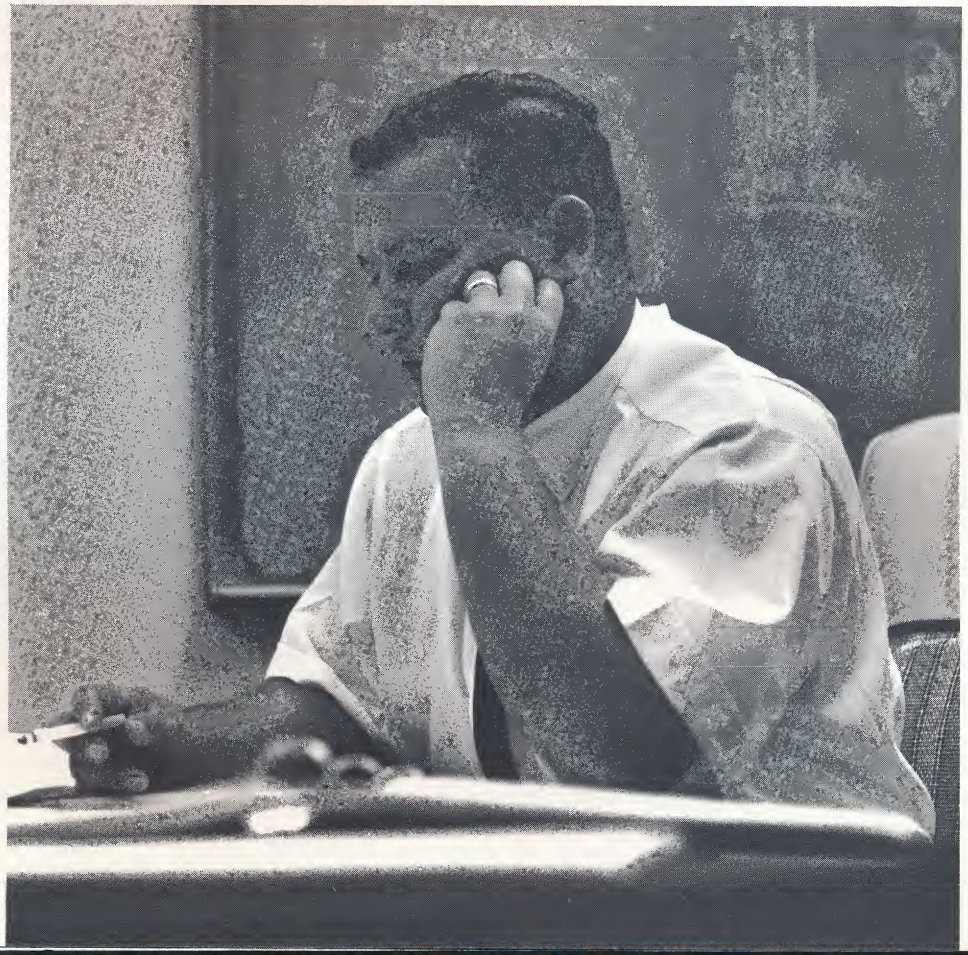
system software

Software programs are used—again and again and again—in preparing other programs and in operating computer systems. The men at PRC who write these programs are forming tools other programmers use to make coding easy and accurate, and tools operators use to make systems function efficiently.

The importance of quality in software is underscored by the words "again and again and again." Programmers use FORTRAN and JOVIAL compilers many times over a period of days, sometimes months, in preparing a program. And programmers are too valuable to be hindered by a compiler with incomplete capabilities. Computers do thousands, sometimes millions, of operations in a minute. And computer time is too expensive to be wasted in executing unnecessary instructions that may be incorporated in an inefficient master control program.

Both computer manufacturers and users turn to PRC for high-quality software. Manufacturers want standard software packages that will be part of the computer system they have for sale. Users want software to extend the capability of their equipment. Both want quality, of course, but a competitive market position is also vital. Manufacturers buy PRC software because there is no higher quality for sale; computer users buy PRC software because there is no lower price with quality.

A generalized software package made up of a compiler, a control system, and a data processing program provides the basic tools needed to solve the problems connected with computer programming and operation. Two outstanding benefits accompany the purchase of an integrated package designed as a total system: the package is economical because of common subroutines found in the package; and the interface problems between compiler, control system, and processing program can be solved during planning rather than during system debugging.



Compilers

Software development at PRC has taken two directions: quality improvement and cost reduction. Because of programming advances, PRC is able to offer compilers with high speeds, complete debugging aids, and sophisticated code optimization routines — all tailored to individual computer characteristics. Because of a recent breakthrough in the design of syntax-oriented compilers, PRC is now able to offer efficient compilers at a considerable reduction in price without sacrificing object code optimization. Syntax-oriented compilers run faster and generate more efficient object programs than other compilers. Planning Research offers to prepare ADAPT, APT, ATOLL, COBOL, FORTRAN, JOVIAL, PL/I, and STOL compilers for computer users or manufacturers.

Master Control Systems

PRC prepares master control systems to ensure that computer systems are accurately set up, well regulated, and scheduled in accordance with the users' wishes. In operation, the master control system operates a computer system at maximum efficiency and processes status interrupts in such a way that jobs are accomplished in order of priority. In one example, a system containing 170,000 instructions, which operates with close interaction between complex system elements, is controlled by a PRC program. The master control system in this example performs the following functions:

- Control and schedule the EDP system
- Control and execute input-output operations
- Maximize system throughput within the limits of user-defined priorities
- Control operations to allow simultaneous on-line and off-line processing
- Reallocate equipment resources to allow for system degradation
- Provide optimal allocation of equipment resources
- Maintain a job list and logs of data files

Information Processing

PRC's experience in the use and construction of information processing systems has resulted from many programming tasks that included such routines. Generally, information processing software prepared by Planning Research for file maintenance and storage and retrieval operations includes these components:

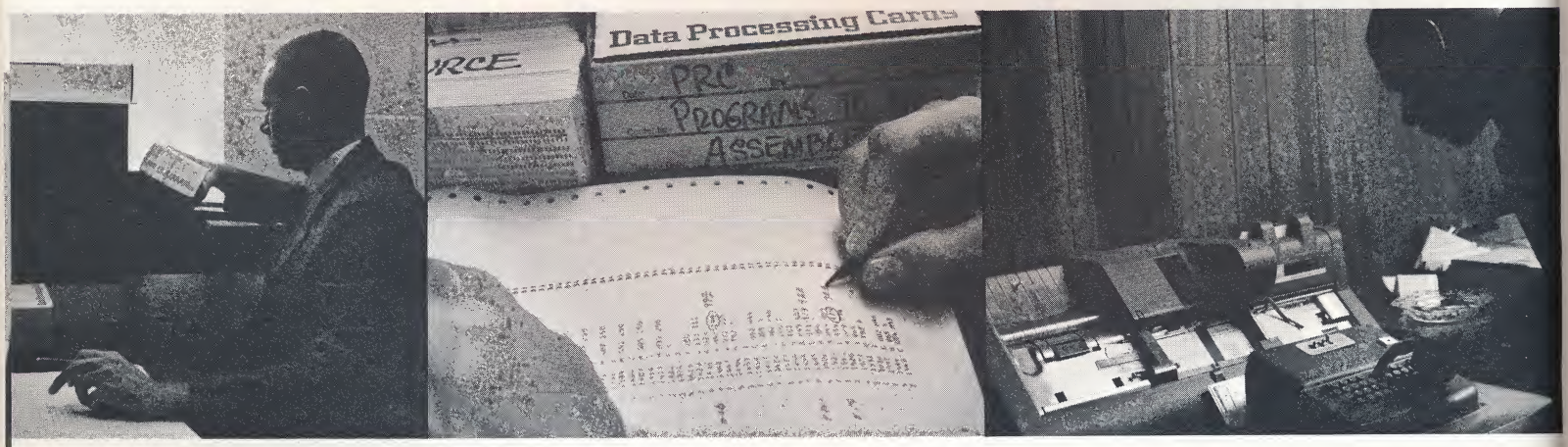
- A file structure, to index and contain information
- An input language and technique, to enter new information into the system
- An interrogating language and technique, to retrieve stored information
- A processing package, to execute information processing tasks, to specify processing algorithms, and to control system operation

The file structure may be a string of related facts or a highly structured representation of given situations. A choice of input and interrogating languages extends from binary, through several compiling languages, to direct English access. The processing package may be based on index terms, frequency counts, semantic analysis, hierarchical structure, or any combination of these. And the control language may be nonexistent (requiring frequent manual intervention) or self-scheduling (with priority assignments and dynamic storage allocation).

Utility Programs

Planning Research writes utility programs that are necessary to the programming process itself. These programs are written in whatever language is convenient to the programmer, as an aid for generating and testing his problem program. Master control system utility programs prepared by PRC include executive and monitoring routines, input-output packages, sort-merge programs providing a multitape sort, and tape-copy and card-to-tape routines. Compiler utility programs are developed to test object code generated by PRC compilers. Utility programs may include subprograms for generating a systemwide data dictionary, and environment simulation aids and data reduction tools for program testing.

Command and Control PRC has provided assistance to many of the large command and control systems now in use or under development for the Department of Defense and civilian agencies. PRC has experience in every facet of command and control development including the analysis of operational requirements, functional design, design of displays and communications equipment, program design and implementation, data base preparation, and personnel training. The systems developed by PRC range from tactical systems for control of specific weapons and missions to strategic systems supporting the highest levels of the national command authority. Examples include antisubmarine warfare mission-control systems, satellite control systems, a system supporting the commander of an advanced attack submarine, a system for an operational fleet commander, and a number of systems supporting the staffs of unified, specified, and component commands. Most of this work has been performed by on-site staffs working closely with the ultimate users of the system.



Intelligence PRC prepares large, complex filing systems that automatically organize, store, retrieve, process, and display intelligence data. Many procedures used are common to other large-scale storage and retrieval projects, but some problems unique to this field require special solutions. For example, PRC developed a reporting format for photo-interpreters. A simplified reporting language records data concerning 34 parameters of security information. Data reduced by this technique are sufficiently organized to permit fact correlation by machine and semi-automatic followup of any activity reported to the system. A further development will lead to an automatic indexing and abstracting program to enable machine examination of unformatted data. Combined linguistic and mathematical techniques assess the significance of words, phrases, and sentences.

Logistics Planning Research Corporation has been working in the field of logistics since the formation of the company in 1954. System studies and computer programs have been designed and implemented for elements of the Army, Navy, Air Force, and several unified commands. Recently, PRC has become increasingly involved in the application of computer systems to the field of combatant logistics. PRC-developed systems include major lift analysis, lines of communication analysis, underway replenishment, and unit loadout feasibility analysis. Another major program category is that of supply, where emphasis is on the specific qualities of the material involved in the logistics process. Although the transportation of material may be ensured through study at the gross-tonnage level, the adequacy of this material to meet current requirements must be determined at the line-item level. This problem is probably most acute in the field of conventional ordnance, where programs have been developed to form an integrated system for resources monitoring, material requirements computations, and resources versus requirements matching.

Management Information Systems

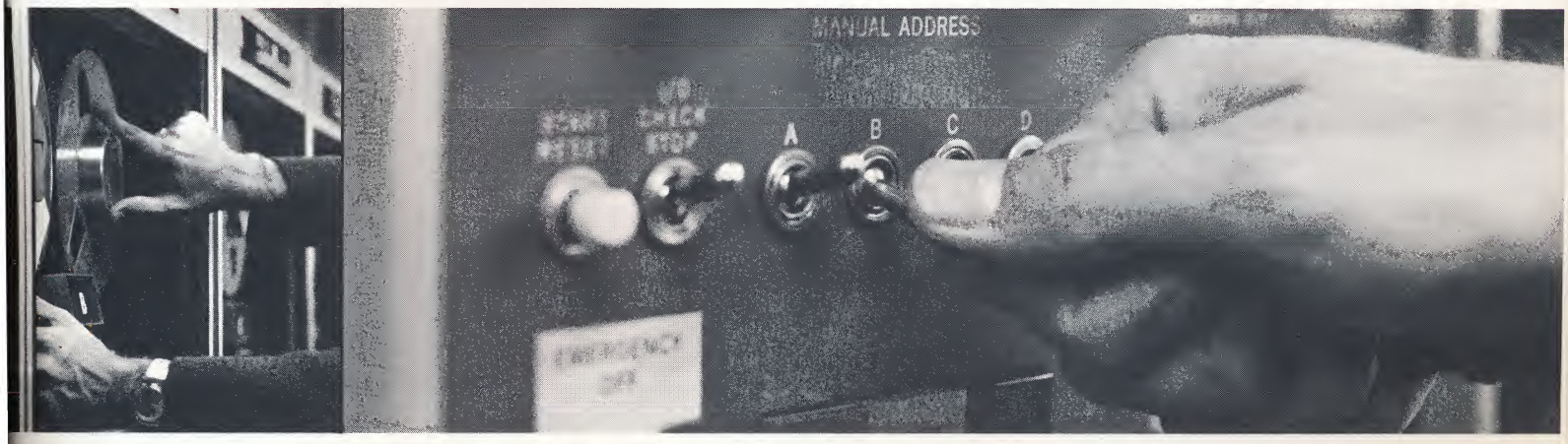
"Management information systems" refer to formalized activities within military and nonmilitary organizations. Typical of these are military command-control systems; however, almost any major management function within a civilian government agency or private enterprise operates as a management information system. PRC has participated in the analysis and development of many such systems. These efforts usually involve thorough study of the existing management procedures of a given system and identification of areas which clearly can be aided through some form of automation. Recommended implementation plans are developed that take into account fiscal limitations and the considerations of phased hardware and software acquisition, communication system modifications, new or altered interfaces with other activities, personnel training, new space requirements, and documentation support. In many instances these studies have been conducted on-site where a first-hand knowledge of operating variables can be gained and solutions can be derived mutually with the system users.

Numerical Control

In the automation of processes, Planning Research has programmed computers to control automatic tools, manufacturing processes, typesetting machines, high-speed aircraft on terrain-following missions, and many other applications. APT and ADAPT programs are written and postprocessors are developed that are capable of transforming blueprint data into tape instructions for automatic tools. Manufacturing processes such as filament winding, welding, mathematical lofting, and flame cutting are also programmed for numerical control by PRC. Automatic line justification and hyphenation programs have been written that have proven to be the most accurate known — in operation, the typesetting algorithms were five times as accurate as demanded by the specifications.

Information Storage and Retrieval

Most of PRC's computer system projects involve information storage and retrieval programs, but in some special instances the entire purpose of a system is to maintain large files of easily accessible information. An example is a current PRC project in which the entire punched card file of a land title insurance firm is being converted to magnetic recording media. The present system handles 6,000,000 entries on punched cards, and it updates the data base at a rate of 800 cards a minute — space and time requirements too great to be handled efficiently. PRC is programming a system based on data cells for the microfilm reference file and on disc packs for the programming system and its permanent records. File input, which consists of punched cards made from the county recorder's records, will remain unchanged. And file output, which consists of a search list and prints of required microfilm for the title officer, will remain unchanged. The resulting computer-based title file will provide 100 percent search accuracy. The new system will reduce by many times the storage space required, and will reduce search time to seconds.

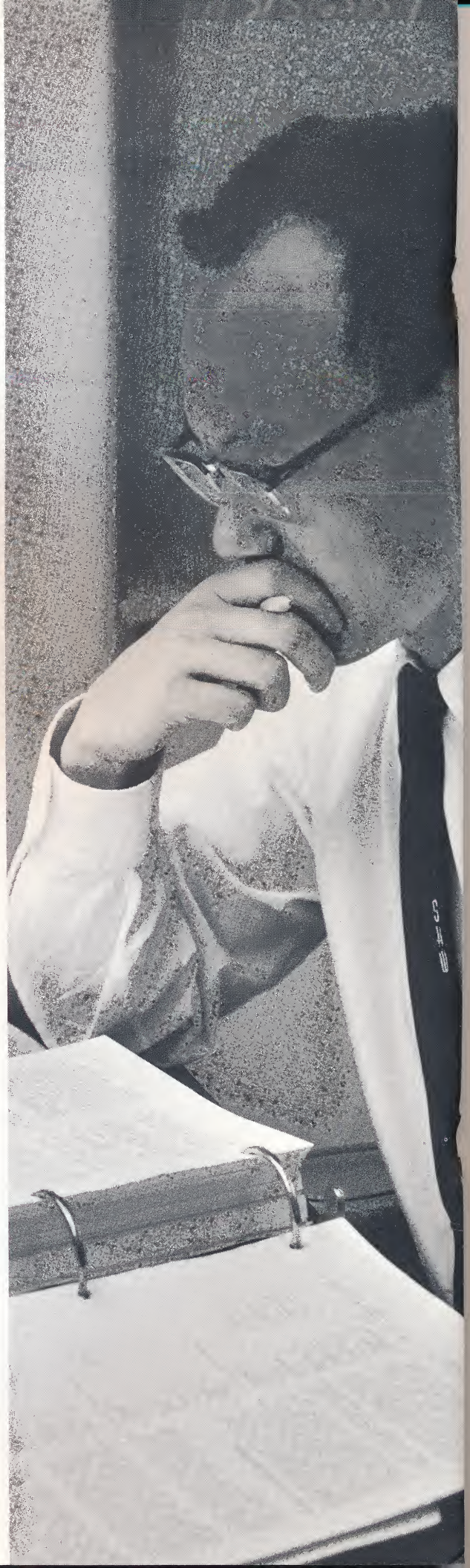


real-time systems

In all likelihood, the single area of greatest impact of computers in the next decade will be on-line, real-time systems, in which the computer functions at the same time that events occur in the system, and continuously and rapidly controls system operations. Planning Research Corporation is preeminent in this area, which includes manned spacecraft control, automatic checkout of space boosters and satellites, emergency military command posts and missile-range systems, industrial process control systems, and on-line management and business information systems. PRC alone among similar companies possesses the electronic engineering, digital systems engineering, aerospace and industrial process experience, and analysis capability that must be available during real-time systems programming, executive control, and display programming activities.

Because of PRC's expertise in digital systems engineering and operations analysis and its unparalleled strength in real-time systems programming, the Corporation has been called on to implement more than 60 real-time computer systems. These include comprehensive automatic prelaunch checkout and data acquisition systems for the Saturn S-IVB and Saturn V space boosters and for Ranger, Mariner, and Surveyor spacecraft; jet engine test stands; hypersonic wind-tunnel systems; and systems for factor product checkout and manned orbiting vehicles. PRC has developed STOL, ATOLL I, and ATOLL II checkout languages to facilitate the test engineer's computer programming. Planning Research programmers, engineers, and mathematicians are responsible for the central data processing, target prediction and acquisition, and control of radar, navigation, communication, and display equipment on the Apollo reentry instrumentation ships operating in the Western Pacific and Indian Oceans. Other real-time programming assignments are

- Aircraft navigational computer software, capable of present-position, Great Circle, and TACAN computations, Lambert mapping, horizontal display, dead reckoning, Doppler computations, cruise control, and inertial navigation
- A closed-loop, real-time control program for an ethylene plant, consisting of 49 closed-process loops for columns, furnaces, compressors, and turbines
- A refinery products pipeline system that handles scheduling and data reduction functions
- A submarine fire control system to support the real-time simulation of maneuvering vessels and of resultant transducer outputs
- Store-and-forward message-switching systems for the U.S. Naval Fleet
- Shipboard data acquisition and navigation systems involved in oil exploration



applied research

Planning Research devotes part of its effort to advanced research on data processing techniques. Such investigations are necessary to keep pace with hardware development and to break implementation bottlenecks. For several years, PRC has been conducting inventory theory research and applying the results to Navy automatic supply system problems. Inventory theory research has produced the dynamic programming of multi-echelon inventory decisions models, the development of Monte Carlo inventory simulation, and the exploration of maximum likelihood estimation techniques. Another research area is modifying the Bayes theorem to allow formulation of a methodology of inductive reasoning. A practical application of this modification is optimal decision making by computers. Air Force and Navy commands are sponsoring further research along this line by Planning Research. Another research project is concerned with mechanical linguistics for a parametric compiler. In theory, a single translation algorithm could be prepared, which would be capable of being conveniently parameterized for various source language/target language pairs.

computer engineering

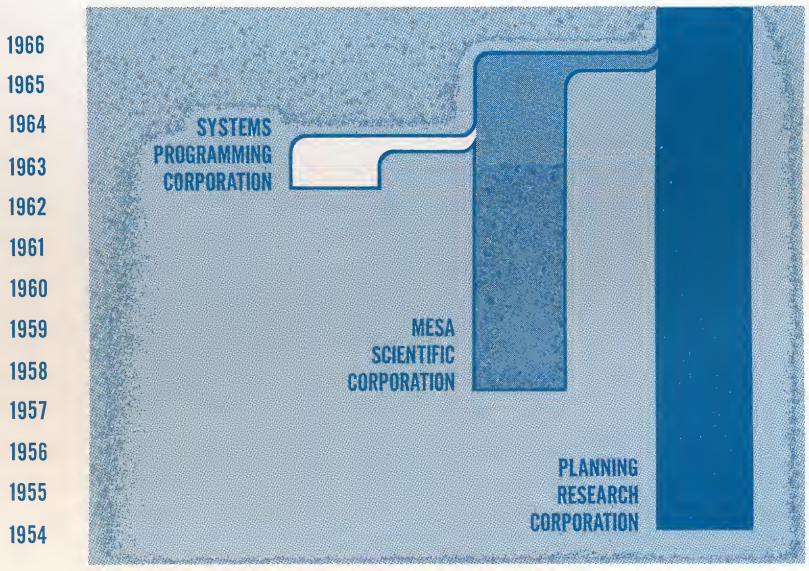
Effective programming of digital hardware for a given application is often compromised by a poor fit between task and hardware. Planning Research has developed a team of computer engineers who can design the circuits and logic necessary to match computers to sensors. Such engineering has been done for missile checkout systems, transient circuit analysis equipment, telemetry monitoring hardware, disc memory checking, and many other applications. Design engineering has been performed by PRC staff members for whole computer systems and for subsystems such as a highly stable, square-wave, variable-frequency generator; a high-speed analog sample-and-hold circuit; and a high-power clock pulse driver. PRC has written design automation software programs for circuit design, logic simulation and load analysis, and electronic chassis and wire harness design. Three critical problems are forcing electronic and aerospace manufacturers to turn more and more to design automation: (1) The supply of electrical engineers and draftsmen is short now and promises to worsen. (2) Time to develop a commercial or military product is shrinking. (3) Many contracts contain time-penalty clauses to enforce delivery dates.

corporate background in computer systems

Planning Research Corporation was founded in 1954 by a group of scientists who wanted to solve technical, military, and commercial problems on a businesslike basis. Now publicly owned, PRC has become a commercial and an intellectual success in an area of professional service once largely dominated by government-subsidized laboratories.

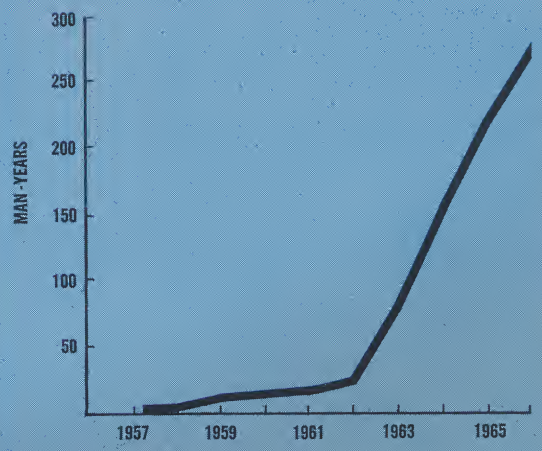
More than half the PRC technical staff now works exclusively with information systems. Special skills have been developed at PRC in logistics, intelligence, command and control systems, and system software programming. In 1965, Planning Research acquired Mesa Scientific Corporation to round out its computer systems capabilities. Mesa personnel formed the nation's most experienced programmer team in such fields as real-time systems, automatic checkout, and computer engineering. In addition, Mesa had developed software programming techniques complementary to those of Planning Research. The chart below shows the PRC family tree.

Throughout its history, PRC has had a special advantage in that its computer specialists could turn to specialists in other fields when the need arose. When a contribution to a computer project is needed from economists, engineers, or other scientists, PRC's small-company versatility allows the needed men to be assigned for as long as necessary to the programming team. On the opposite page, a listing of professional subjects and degrees shows the disciplines in which staff members have gained competence. Also on the opposite page are charts that indicate Corporate and individual experience in computer systems work. Programmers at Planning Research average 6 years' experience, and the average for computer systems analysts exceeds 10 years' experience with computer-based systems.

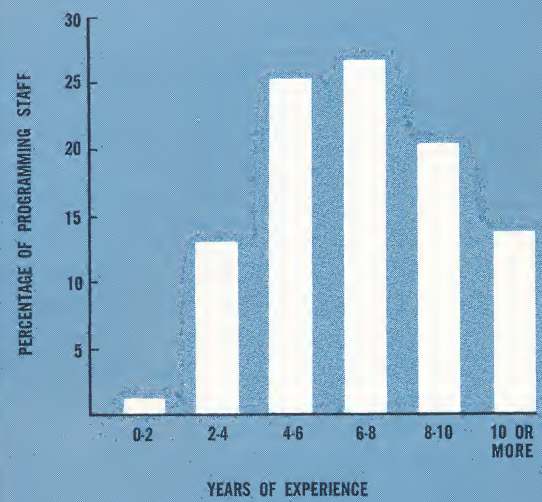


PROFESSIONAL PERSONNEL: SUBJECTS AND DEGREES

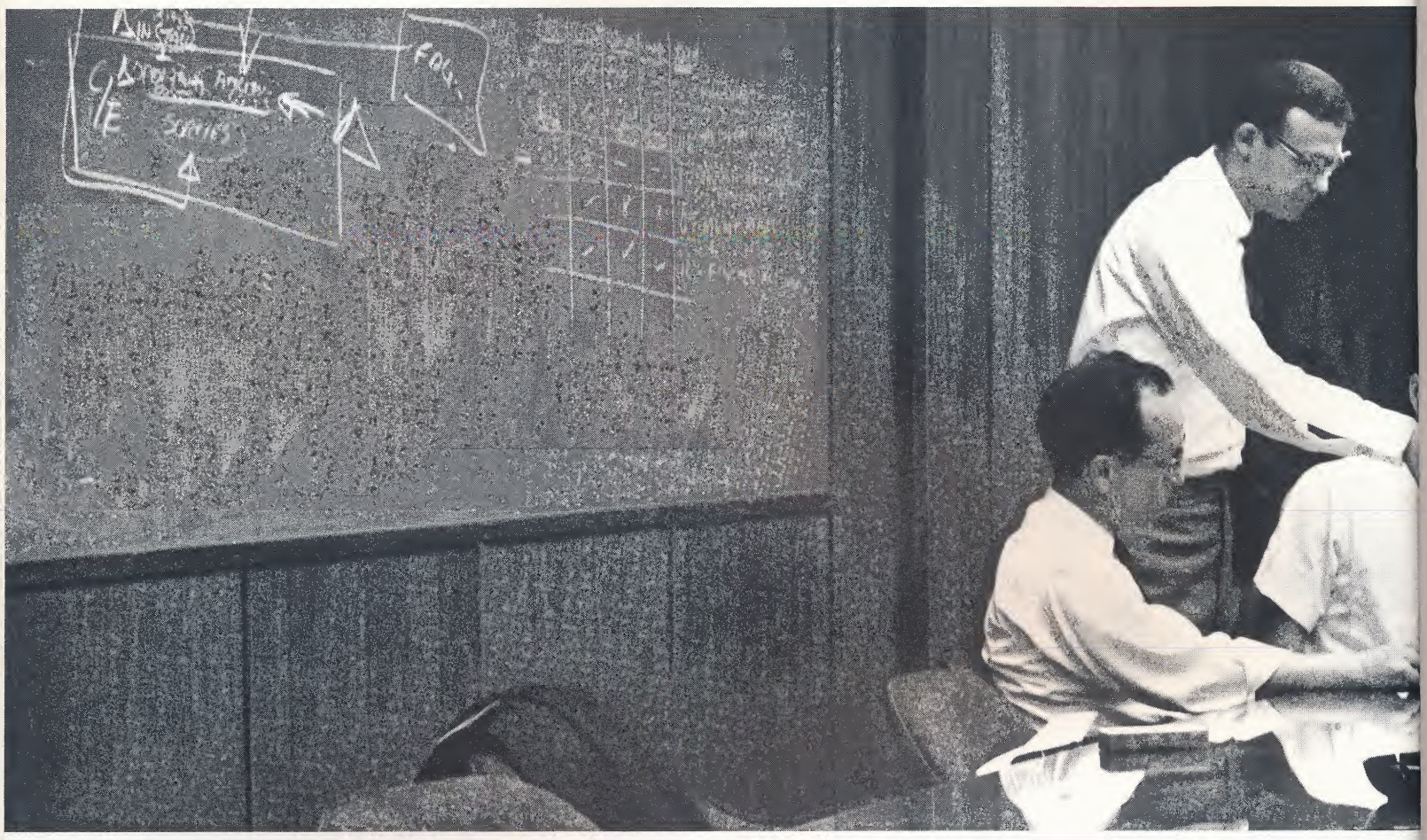
	PHD MD	MA-MS MBA LLB	BA-BS BLS	NDN-DEGREE	TOTAL
MATHEMATICS					
MATH	7	32	108	53	200
STATISTICS		2	5	2	9
PHYSICAL SCIENCES					
CHEMISTRY		1	7	4	12
PHYSICS	3	6	24	1	34
GEOLOGY			3	2	5
METEOROLOGY			4		4
ENGINEERING					
AEROSPACE	2	3	6	1	12
CIVIL		3	3		6
ELECTRICAL	1	20	38	2	61
INDUSTRIAL	1	3	3	2	9
MARINE			1		1
MECHANICAL		8	15		23
OTHER		1	2	1	4
LIFE SCIENCES					
MEDICINE	4				4
PSYCHOLOGY	10	5	9		24
ZOOLOGY			2		2
SOCIAL SCIENCES					
BUSINESS ADMINISTRATION	1	17	15	8	41
ECONOMICS	4	9	15	2	30
GEOGRAPHY		1			1
HISTORY		2	3	1	6
PHILOSOPHY	1	1	1		3
POLITICAL SCIENCE		1	5		6
MISCELLANEOUS					
EDUCATION		3	5		8
ENGLISH		1	7	1	9
ILLUSTRATION-DESIGN			2		2
LAW		4			4
LIBRARY SCIENCE		1	1		2
OPERATIONS RESEARCH	1	3	1		5
TOTAL PROFESSIONAL PERSONNEL	35	127	285	80	527
TOTAL PERSONNEL					719



AVERAGE ANNUAL CORPORATE EXPERIENCE IN COMPUTER SYSTEMS ANALYSIS AND PROGRAMMING



EXPERIENCE OF COMPUTER SYSTEMS STAFF MEMBERS



corporate management

PRC's continuing profitable growth is the best evidence of management's serious ambition for technical excellence. Clients for whom performance is of primary importance continue to make more and more requests for the services of the staff.

The principals and the entire technical management team are scientists and computer specialists. They run a business with annual revenues exceeding $15,000,000, with the focus of the entire organization aimed at providing the best technical product possible. In the area of computer systems, a senior vice president has full-time responsibility for organizing the technical effort. His decisions mobilize the resources of a competent, multimillion dollar organization to meet clients' requirements, and to adapt quickly to changes of schedule and scope.

Management philosophy at PRC consists of assigning contract responsibility to men who are able to communicate with the client's staff and consider the problem from the client's point of view. Management takes a total systems approach — design, programming, training, documentation, and any other task needed for an integrated product. To ensure that system operation will be as planned, PRC personnel usually spend a considerable portion of their time on-site. And to ensure continuity of system development, PRC has the capability to participate in every phase from initial design to system turnover.

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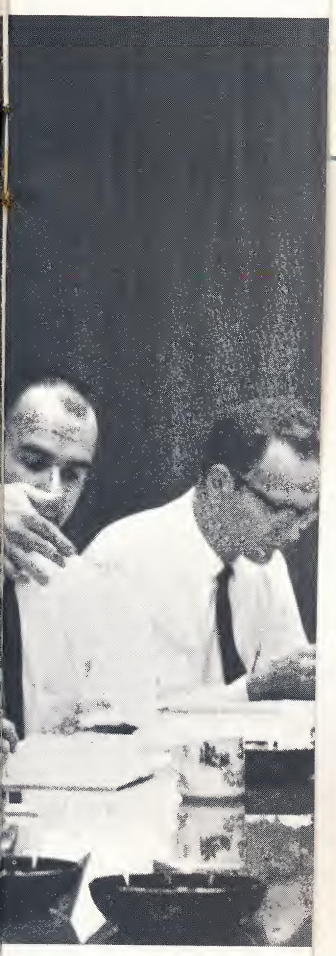

clients

ADVANCED SCIENTIFIC INSTRUMENTS
AEROSPACE CORPORATION
AMPEX CORPORATION
ATLANTIC REFINING COMPANY
AUTONETICS
BELL AEROSPACE CORPORATION
CALIFORNIA LAND TITLE COMPANY
CONSOLIDATED ELECTRO-DYNAMICS CORPORATION
DEPARTMENT OF COMMERCE
DOUGLAS AIRCRAFT COMPANY, INC.
ELECTRO-OPTICAL SYSTEMS, INC.
FEDERAL POWER COMMISSION
GENERAL DYNAMICS ELECTRONICS
GENERAL ELECTRIC COMPANY
GENERAL MOTORS CORPORATION
GENERAL SERVICES ADMINISTRATION
GRUMMAN AIRCRAFT ENGINEERING CORPORATION
HOFFMANN ELECTRONICS CORPORATION
HONEYWELL, INC.
HUGHES AIRCRAFT COMPANY
INTERNATIONAL BUSINESS MACHINES CORPORATION
ITT COMMUNICATION SYSTEMS, INC.
JET PROPULSION LABORATORY
LEAR SIEGLER, INC.
LIBRARY OF CONGRESS
LIBRASCOPE
LING-TEMCO-VOUGHT, INC.
LITTON INDUSTRIES, INC.
LOCKHEED AIRCRAFT CORPORATION
MAGNAVOX COMPANY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NEW BRITAIN MACHINE COMPANY
NORTRONICS
OCCIDENTAL LIFE INSURANCE COMPANY
PACKARD BELL ELECTRONICS CORPORATION
PHILCO CORPORATION
PORT OF LONG BEACH, CALIFORNIA
RADIO CORPORATION OF AMERICA
RANCHO LOS AMIGOS HOSPITAL
THE RAND CORPORATION
RAYTHEON COMPANY
RYAN AERONAUTICAL COMPANY
SANDERS ASSOCIATES, INC.
SHELL OIL COMPANY
SOUTHERN CALIFORNIA GAS COMPANY
STANFORD RESEARCH INSTITUTE
TECHNICOLOR CORPORATION
THOMPSON RAMO WOOLDRIDGE INC.
UNITED AIRCRAFT PRODUCTS, INC.
UNITED ELECTRODYNAMICS, INC.
UNITED STATES AIR FORCE
UNITED STATES ARMY
UNITED STATES NAVY
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